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A STANDARDS-BASED APPROACH TO TEAM-BASED STUDENT PROJECTS IN AN INFORMATION TECHNOLOGY CURRICULUM

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ABSTRACT

Team-based student projects have become an intrinsic part of coursework in information technology courses. The rationale is that once students enter the work environment they will be required to work in teams. Challenges of teamwork are reviewed and factors influencing student team performance are identified. An approach is described which deals with four categories of concern when incorporating a team-based project in information technology courses, namely planning, execution, evaluation and team process improvement. The approach stresses the importance of utilizing best practices, as available in international standards, for team projects of a full term duration that is based on a case study. It is argued that such an approach contributes to bridging the gap between student project teamwork based on limited case studies and real-world projects conducted in the competitive business environment of today. The best practices and standards used in 34 classes for eight courses of a master's program in computer and information systems are summarized in the paper. A total of 150 teams participated in these courses.

INTRODUCTION

Team-based student projects have become an intrinsic part of coursework in information technology (IT) courses (Meyer, 2001; Stephens, 2001). The rationale is that once students enter the work environment they will be required to work in teams. Working in a team context challenges team members in a number of ways, such as:

- Teams are composed of individuals with different technical skills, cultural backgrounds, behavioral characteristics, cognitive styles and learning abilities.
- Performance of team members is influenced by the level of teamwork and in-field experience, knowledge of the application domain, pressures of schedule, geographical dispersion, full-time or part-time study.

Various authors have reported on project teamwork in the academic environment (Mennecke et al,1998; Jovanovic et al, 1998; McKendall, M., 2000; Stephens, C. and O'Hara, M., 1999). However, Stephens (2001) has analyzed the literature on student teams finding that a limited number addressed the issue of effective teamwork in the academic context. The fact is that most research equates the experience of student teams with that of professional workgroups despite the fact that the characteristics of the two types of teams are very different. For instance, the control structure, mechanisms for monitoring and managing, and the composition of the two types of teams are significantly different.

A team approach to student projects over a full term has formed part of most of the courses in the master's program in computer and information system at the University of Detroit Mercy. Our experience in 34 IT courses, where teamwork formed part of the pedagogy, has confirmed experiences reported by others (Jones, 1996; Stephens, 2001) regarding the importance of factors such as:

- Thorough planning of the team project
- Appropriate interventions to improve effectiveness of student teams

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- Efficient and effective project team leadership
- Active team member commitment and participation
- Appropriate groupware technologies.

In addition it is our experience that using best practices as available in international standards enhances the quality of the project, the deliverables, and provides a mechanism to enhance the value of the student team experience once a student enters the market place. We argue that the approach presented here contributes to bridging the gap between student project teamwork based on limited case studies and real-world projects conducted in the business environment. By adopting a team approach in projects we intend to support and enhance a student's ability to learn by absorbing the subject matter individually and then applying the knowledge gained in a project as part of a team.

Team process categories structure the aspects relevant to planning and implementing a team-based, project-oriented process, referred to in this paper as the team approach, as part of the course pedagogy. Four team process categories are described that concern faculty when incorporating a team-based project in information technology courses, namely planning (in Section 2), execution (in Section 3), evaluation (in Section 4), and team process improvement (in Section 5). The processes described in the Project Management Body of Knowledge (PMBOK) (PMI,2000) have proved very useful for detailing the activities of planning and executing team-based projects. Team process improvement has been done in accordance to practices of the Team Software Process (TSP) (McAndrews, 2000) and processes recommended in the ISO15504 (1998). Section 6 summarizes the relevant industry standards and best practices used in a range of courses with 150 participating teams, and draws some conclusions.

PLANNING CATEGORY

Activities in this category deal with aspects that should be considered when preparing to incorporate the team approach in a course. A number of questions must be resolved, such as:

- What do you include under planning?
- Factors influencing choice of case study
- Do you have industry involvement?
- What Standards and best practices are used?
- Project materials used
- How do you measure outcomes?
- What software is used?
- Do you support classroom teaching with virtual teaching and learning aids?
- Do you maintain a team process database?
- What are your project deliverables?

Planning a team-based project within the context of the course syllabus requires answers to these questions and attention to aspects such as the ones discussed next.

Faculty should determine the standards and best practices applicable for a course with a team project. These standards are relevant for both the course specific teamwork and the project management tasks to bring the teamwork to successful conclusion. Supporting materials must be prepared for the team project, including tutorial material describing the team project, prerequisite knowledge for each team assignment, the case study to be used, the team assignments, the formats of project deliverables (e.g., a requirements specification document, or a design document), and related information.

Where appropriate an industry specialist could be identified and invited to participate in the course and team project. In some projects industry involvement is substantial in that the case study used for the team project is provided and a measure of support is provided for the teamwork. An example is a case study on the E-Business System of a division of an automotive company which was used in two courses (Steenkamp et al, 2002). In other cases the involvement is in the form of presentations on the application domain of the project.

Teamwork related forms, such as a student background evaluation (SBE) form, a team composition form, peer evaluation form, and related forms must be designed. Some generic formats have been developed and are available for use in project-based courses.

The planning and development of the course website needs to be done once some key materials are ready. At first support in establishing such a course website was provided by the Instructional Design Center at the university. More recently the university subscribed to the Blackboard e-learning software platform and faculty members are now able to develop their own course sites, with the necessary training provided by the Instructional Design Studio. Other e-learning software platforms are available, such as the Learning Space environment used at the ITESM in Monterrey, Mexico which is based on IBM's Lotus Notes (Murillo, 1998).

An important aspect in the planning category concerns the logistics arrangements for teamwork (rooms, projection equipment and internet-ready computer facilities, site visits where appropriate, and the like).

Table 1 summarizes typical activities in the planning category.

THE PROJECT EXECUTION CATEGORY

Once a course starts and a team project is due to commence activities in this category need consideration. Aspects include initiating the team project in class, coordinating teamwork, consulting with teams during the project life cycle, and mechanisms for monitoring teamwork. For teams to be successful in performing the technical tasks of a project it is imperative that they adopt a sound development methodology, with rigorous coverage of development process, representation schemes, notations and format of deliverables relevant to the particular course.

Each of the aspects in the project execution category is reviewed next. Table 2 provides a summary of project execution activities from the perspective of the faculty member.

Project Initiation

This aspect includes activities such as establishing the teams, and orienting them regarding the case study and teamwork. Some questions regarding initiating a team project include:

- How is the project initiated?
- How are teams compiled? Team size?
- How are team leaders identified?
- How are standards and best practices introduced to the teams?
- Do you conduct team tutorials?
- How do you monitor progress?

In some cases a prerequisite course may have provided adequate coverage of team collaboration and virtual

TABLE 1
ACTIVITIES IN THE PLANNING CATEGORY

	Planning Category
1.	Select a appropriate case study for the project that integrates the team assignment.
2.	Obtain industry involvement (case study) and arrange for presentation in course session.
3.	Identify appropriate references on teamwork and the virtual team.
4.	Identify appropriate references that orient, guide and support culturally diverse teams.
5.	Identify and obtain appropriate groupware tools to support teamwork.
6.	Identify and obtain appropriate software tools to support project work.
7.	Prepare tutorial materials regarding the team project, the case study, team members' responsibilities, team assignments and schedule. Include details of assignments, formats of project deliverables and final project report.
8.	Develop course website. Prepare teamwork related forms.
9.	Plan Project Review Exercise and reporting format.
10.	Plan team tutorial sessions.
11.	Make logistics arrangements for resources needed for team meetings.

TABLE 2
ACTIVITIES IN THE PROJECT EXECUTION CATEGORY

Project initiation
Introduce the team concept and provide orientation regarding teamwork.
1. Provide orientation regarding team functions in course website, project tools and project techniques.
2. Review standards to be used in the project.
3. Perform Student Background Evaluation Survey using SBE form.
4. Organize students into teams (team size depends on the number of students in the class but should not exceed 5 persons).
5. Identify team leaders based on student background survey; provide orientation to team leaders; make Team Composition Form available on course site.
6. Identify the role players; provide orientation to role players.
7. Take digital photograph of each team; post on course website.
8. Introduce case study. Where appropriate include presentation by industry consultant.
9. Give orientation on team assignments to full class.
10. Make example team project deliverables available to teams (reference only).
Teamwork coordination
1. Organize schedule of consultations with team leaders; with full team.
2. Implement mechanisms for teamwork participation of all team members.
3. Arrange availability of all project resources (computing, software tools, standards).
4. Arrange project presentation schedule.
Project consultation
1. Hold weekly technical consultations with team leaders.
2. Attend at least one team meeting per week with each team to consult on team-specific, technical issues.
3. Provide role-specific orientation for role players of all teams, and follow-up during project.
Project monitoring
1. Monitor team leadership; take corrective action when necessary.
2. Monitor team dynamics and progress; take corrective action when necessary.
3. Monitor all role players' responsibilities and involvement in project.
4. Monitor team collaboration on course site.

team requirements. At a minimum faculty should review the principles of successful teamwork and teamwork methodology. A schedule should be arranged once the teams have been established for future meetings with team leaders and their teams. The initiating aspect also includes orientation regarding the case study, the context and the scope of the team assignments, and other relevant topics. It has proved useful to make project folders from the archive available to teams for reference purposes, ensuring that such folders are not copied when referenced. These project folders have been stored in an archive as a record of past teamwork.

The first team assignment focuses on teamwork planning following an project planning standard. For most of our team projects standard IEEE1058 (1998) was prescribed (refer also to Table 6). The importance of planning for quality as part of any project was also stressed by prescribing the standard for software quality assurance plans (IEEE730, 1998 in Table 6).

Teamwork Coordination

Coordination of teamwork involves the coordination of teamwork within teams, as well as coordinating work with a number of teams in the class. Coordination centers on logistics involving time, resources and location. Answers should be provided to the questions:

- How is teamwork coordinated?
- Do you appoint team leaders, or does the class choose them?
- Do you assign roles for team members?

- Are teaching assistants involved?
- How do you deal with culturally diverse teams?
- How do you handle inadequate understanding within teams?
- How do you handle dysfunctional teams?

Faculty must work with team leaders to ensure that the necessary computing resources, relevant standards and software tools accessible to all members of the team. An equitable team consultation schedule should be followed (weekly meetings are appropriate), and opportunities should be provided for collaboration among teams. It has become evident that a fair amount of cross-training takes place within teams and also among different teams, all beneficial to the overall learning experience.

Project Consultation

Supporting the technical development work of a team project has proven to be most challenging. Some teams with skills and experience in the technical tasks of the project may need limited support. Such teams conduct productive team meetings and produce quality deliverables on time. They are usually keen to receive detailed feedback on deliverables and have a good teamwork dynamic and consequently high morale. The conditions for learning are clearly high in such team. Other teams struggle to come to terms with the context of team assignments for a case study, and to apply theoretical concepts and knowledge. For example, students may have studied a software design methodology, design processes and notations but still have significant problems to model a design for a given subsystem. If and when problems of this kind emerge faculty must increase the level of consultation and support for a team to ensure a successful team experience.

Questions for this aspect include:

- What issues are team-specific and what are of general concern?
- How do you address such issues? (in class/on the website/ during consultation with teams)
- How do you address responsibilities of role players in teams?
- How do you coach team leaders?
- How do you handle inadequate understanding within a team?

Project Monitoring

It is important to implement mechanisms for monitoring team performance. Although specific roles and responsibilities may have been assigned, the team assignments and the schedule reviewed, occasions invariably arise where team members fail to participate effectively. In some cases participation is irregular; deliverables are late, not according to specification or not submitted by the responsible team member at all. Since all teams have a quality assurance role late deliverables causes immediate frustration since the quality assuror does not have the opportunity to review the work before turning it in for grading. An issues like this one must be addressed as soon as it arises to avoid further conflict.

In planning this aspect questions to be answered include:

- How is team progress monitored?
- How do you deal with team discipline?
- How do you deal with dysfunctional teams?
- How do you deal with a discontented team member?
- Do you use groupware/Internet/course website for virtual team monitoring?

TEAM PROJECT EVALUATION

One hopes to determine the outcomes of a team project in terms of the objectives for the course as a whole.

Questions in this category ask:

- How do you evaluate teamwork?
- What percentage of the grade is based on teamwork?
- What measures do you use?
- How do you distinguish team member contributions?

Evaluation of teamwork usually focuses on the deliverables, but may also include evaluation of the team process (Stephens and Myers, 2000) and team collaboration (McKeage et al, 1999). These authors have proposed intervention mechanisms such as evaluating the team process to improve the effectiveness of student teams. We have used project review exercises also, where a team reviews deliverables of another team in the class, or where all teams review a specific deliverable from the project archive. Other mechanisms to determine individual accountability include team presentations, peer evaluations and participation during team tutorials. Table 3 summarizes typical activities in this category.

TABLE 3
ACTIVITIES IN THE TEAM PROJECT EVALUATION CATEGORY

1. Evaluate team deliverables.
2. Evaluate revised team deliverables.
3. Evaluate final project report.
4. Evaluate project review exercise report.
5. Evaluate team progress meeting minutes (submitted by team leaders).
6. Evaluate team member peer evaluations (submitted by each team member individually).
7. Evaluate team member presentations.
8. Evaluate overall team presentation.
9. Assess each team's experience (based on assessment by each team at the end of term).
10. Assess project outcomes.

TEAM PROCESS IMPROVEMENT

Where teamwork forms part of a course it is desirable to establish a defined team process that represents a baseline according to which teamwork may be planned and performed. Defining the team process and documenting each team experience in a team process database make it possible to benefit from good ideas and techniques while avoiding past mistakes or negative outcomes. We need answers to the questions:

- How do you document project outcomes?
- How do you update your team process database?
- What measure and metrics do you use?

The ISO 15504 standard for software process improvement and capability determination (formerly known as SPICE) and CMMI framework which is an integration framework for mature IT (but mainly) software processes have proved useful as references to establish processes and activities for this category. Table 4 lists some typical activities in this category.

TABLE 4
TEAM PROCESS IMPROVEMENT CATEGORY

1. Adopt an industry standard for team process improvement.
2. Archive all A project reports.
3. Archive all A project prototypes.
4. Review teamwork approach (all phases) and analyze students' responses to teamwork experience.
5. Update team process database with project data.

Guidelines regarding how to deal with differences in competence and skills among team members, how to deal with ethnically and culturally diverse team members, resolution of conflicts within teams, alternatives to teamwork in a project-oriented class are valuable for planning team-based, project-oriented courses.

DISCUSSION

The team-based, project-oriented approach described in this paper has matured over a number of years in project-based courses in software engineering, requirements engineering, software design, database design, software process management, software quality assurance, system and information technology architectures, and software system metrics. Data on 34 project-based classes has been accumulated representing teamwork by 150 teams. A comparative evaluation of

the team project outcomes of the courses in general, and of the deliverables of specific courses over a number of semesters has revealed a substantial improvement in quality. This quality improvement is partially attributed to the structured project-oriented approach and the use of standardized notations, as well as to the software development methodologies that were adopted in the respective courses.

Table 5 summarizes the standards and best practices used to guide teamwork in the listed courses. Projects were conducted by teams following a three stage process: project planning, project execution, and project review. Industry standards relevant to the tasks and activities of the three stages are provided in Table 5. Using the best practices embodied in these standards has provided faculty with a mechanism to introduce some measure of real-world exposure in the class room. Feedback from graduates who are employed in the IT industry, though very positive, needs to be surveyed to quantify the outcomes of this team approach.

As may be seen in Table 5 planning was a key category for all projects, requiring all teams to use IEEE Std 1058 for planning the teamwork, supported also by the IEEE Std 730 for planning software quality assurance. For the Software Quality Management course the ISO9001 standard was also used for planning the project work. For the course in Software Process Management the organizational life cycle processes of the ISO 12207 Standard and the processes in the process improvement category of the IEEE Std 1074 were used for planning software process improvement projects. Project execution was supported by a range of standards dependent on the course subject. Project evaluation was guided by two standards among a number of other competing ones, namely ISO 15504 and IEEE Std 1028. The project management body of knowledge is documented in detail by PMI (2000) and in IEEE Std 1490 (1998). Although this is a general project management reference the processes described there apply to IT projects also and are valuable for student projects. The Software Engineering Institute, Carnegie-Mellon University has published a number of capability maturity models with key process areas in each of the team process categories discussed in this paper. Exposure to these models provides an additional advantage when conducting team projects for courses other than software process management.

Further analyses of the team project data are planned to determine, for example), team performance versus individual performance of team members in a team, performance of teams in different sections of a particular course, individual performance of team leaders versus performance as team leaders of a team, and similar analyses.

TABLE 5
STANDARDS AND BEST PRACTICES ADOPTED FOR TEAM PROJECTS

Courses	Project Planning	Project Execution	Project Review
Requirements Engineering	IEEE730	PMBOK	ISO15504
	IEEE1058	IEEE830	IEEE1028
Software Design	IEEE730	PMBOK	ISO15504
	IEEE1058	IEEE1016	IEEE1028
Database Design	IEEE730	PMBOK	ISO15504
	IEEE1058	IEEE1016	IEEE1028
Software Process Management	IEEE1074	IEEE1074	ISO15504
	ISO12207	ISO12207	IEEE1028
Software Quality Management	IEEE730	ISO9000	ISO15504
	ISO9001	ISO12207	IEEE1028
Software/IT Architectures	IEEE730	IEEE1471	ISO15504
	IEEE1058	IEEE1220	IEEE1028
Software Metrics	IEEE730	IEEE1045	ISO15504
	IEEE1058	IEEE1061	IEEE1028

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